보건학석사 학위논문

A Multilevel Analysis of Physical Activity and the Local Environment in Seoul, Korea

다수준분석을 이용한 서울지역에서 신체활동과 지역특성과의 연관성

2012 년 8 월

서울대학교 보건대학원

보건학과 역학전공

박 지 원

A Multilevel Analysis of Physical Activity and the Local Environment in Seoul, Korea

지도 교수 조 성 일

이 논문을 보건학석사 학위논문으로 제출함

2012 년 4 월

서울대학교 보건대학원

보건학과 역학전공

박 지 원

박지원의 보건학석사 학위논문을 인준함

2012 년 8 월

위 원 장 ______ 김 호 ______ (인)

부위원장 ______ 정 효 지 ______ (인)

위 원 ______ 조 성 일 ______ (인)

Abstract

Jee Won Park
Public Health, Epidemiology
The Graduate School of Public Health
Seoul National University

Background: Physical activity has been shown to reduce the risks of chronic diseases. Hence promoting physical activity is a public health priority and there are growing interests in implementing environmental factors to promote physical activity within the community. This study examines environmental factors affecting engagement in recommended levels of physical activity.

Methods: A sample of 22,232 subjects (9,930 male, 12,302 female) with a mean age of 45.9±16.0 residing in 25 Gu in Seoul were collected from the 2010 Community Health Survey. Environmental factors ranging from local exercise areas to total area of green space were collected from the City of Seoul's Statistics database. Multilevel logistic analysis was conducted to explore whether environmental characteristics were associated with physical activity.

Results: Overall, 31.4% of subjects met the guidelines for physical activity. Multilevel analysis showed only private facilities per 1,000 people was associated with physical activity (OR: 1.28, 95% CI: 1.04-1.58). Significant variance of physical activity was present between areas, and after adjustments of individual-level factors, the variance decreased, and inclusion of community-level variance, the variability between communities was further reduced.

Conclusion: This research shows that the number of facilities available for physical activity in communities has a positive association with meeting physical activity guidelines. However, there was no evidence of an association between other environmental characteristics and physical activity.

Keywords: Physical activity, physical environment, built environment, multilevel analysis, community health, Korea
Student Number: 2010-23809

Contents

Tables

Figure

Chapter 1. Introduction

1-1. Background

Participation in regular physical activity has been shown to improve health and reduce the risk of developing many chronic diseases, including coronary heart disease, stroke, diabetes, hypertension and some forms of cancer, and these are one of the leading causes of death in many countries, and also in Korea (WHO, 2009). Several reports in the past have recognized that sedentary lifestyles and dietary factors are responsible for approximately 22%-30% of cardiovascular deaths, 20%-60% of cancer deaths, and 30% of diabetes (Stone et al, 1998). In the United States, Hahn et al (1990) estimated that more than 250,000 deaths per year are due to physical inactivity alone, and McGinnis and Foege (1993) estimated that more than 300,000 deaths are due to the combined effect of physical inactivity and unhealthy diet. Hence, the importance of promotion of physical activity in the community has been shown in several studies, and is a high public health priority (Humpel et al, 2002).

Most common forms of physical activity, such as jogging are considered to be done in a community or a neighbourhood context (Li et al, 2005). Studies that have focused on individual demographic factors such as age, gender, education and income were thus unable to explain physical activity, and the surrounding environments were considered as possible contributors to physical activity (Prince et al, 2011). Therefore, the association between area of residence and physical activity has become an important area of research based on evidence from past studies suggesting that physical activity is differential for neighbourhoods (Heinrich et al, 2007).

In the U.S., as well as internationally, intervention policies and strategies that are capable of changing local environments to support physical activity are identified as an important component to health promotion (Hoehner et al, 2011). This is because a focus on environments that change communities to support physical activity may have positive effects on personal health and well-being to the whole population within that community (Bentley et al, 2010). Also, examining the distribution and determinants of physical activity that can be changed to have a positive influence is a necessary process for researchers to inform in developing policies and effective interventions in the community (Sallis et al, 1998). Previous studies have shown several domains of physical activities that are likely to have an influence: demographic and biological, psychological, cognitive and emotional, behavioural attributes and skills, social and cultural, physical environmental, and physical activity characteristics (Dishman and Sallis, 1994; Sallis and Owen, 1999; Humpel et al, 2002). Of those seven categories, the physical environment factor was a relatively new topic that was least studied, with growing interest by both researchers and policy developers to implement intervention strategies, which could lead to promoting physical activity in the population (Sallis et al, 1998).

In addition, the Institute of Medicine's report on childhood obesity prevention, as well as the Transportation Research Board, and the US Preventative Services Task Force identified the environment as an important characteristic for promoting physical activity in communities as well as in areas with a high-risk population, and recommended improving environmental and policy strategies to increase opportunities of physical activity within communities (Norman et al, 2010; Trilk et al, 2011). Accordingly, Public Health programs are gradually putting efforts into introducing and modifying policies and environmental interventions, such as increasing safety of local streets, footpaths, or increasing access to both indoor and outdoor physical activity facilities in order to influence individual physical activity behaviour and provide adequate resources in neighbourhoods that are supportive of a healthy lifestyle (Huston et al, 2003).

There are evidence, mainly from general adult populations that have shown the relationship between features of the environment and physical activity. A number of studies have shown that the access and number of recreation facilities were associated with leisure-time physical activity (Owen et al, 2000; Sallis et al, 1990; Santos et al, 2009), although Sallis et al (1990) found significant association between exercise facilities and frequency of exercise, and Santos et al (2009) showed that a composite measure of the environment that included infrastructure, destinations, social environment, and aesthetics were significant positive predictors of walking.

Previous studies on green space and parks, which are areas providing opportunities for physical activity for everyone in the community have shown evidence of an association with physical activity. In addition, availability of green space was related with walking (Cohen et al, 2009). In another study of adults in South Brazil, the authors showed that existence of green areas around households were associated with leisure-time physical activity, but not with physical activity in transportation (Amorim et al, 2010)

The social ecological perspective of environmental influences of physical activity suggests that people' s behavior is affected by factors that act on multiple levels, consisting of personal, socio-cultural, environmental, and policy levels (Ries et al, 2011). Hence, the instead of the conventional individual-level approach, a multi-level approach is considered to separate the variance of physical activity between different levels that provides more precise results (Fisher and Li, 2004).

There are many studies demonstrating a positive association between facility availability and physical activity.

Most of the research on the subject of contextual features of the environment and physical activity has been conducted in the U.S., Australia, and Canada. Although evidence regarding the importance of local environments for physical activity in other countries is growing, it remains relatively sparse. As the environmental attributes may differ in various countries (Deforche et al, 2010), the associations observed in the U.S. or Australia are not generalizable to other populations, and hence, more international researches are needed.

Korea has undergone rapid urbanization in the past few decades, and chronic diseases such as cancer, stroke, and coronary heart disease are the leading causes of death in addition to many other chronic diseases are becoming prevalent (Statistics Korea, 2010). The capital city of South Korea, Seoul, is one of the most densely populated cities in the world, where individual households usually do not have sufficient area for physical activity. According to the 2010 Community Health Survey Report, 18.5% of the participants in Seoul participated in moderate-to-vigorous activity*, and this has declined from the previous year of 19.1%. However, there are only a few researches assessing the association between physical activity and local environment conducted in densely populated urban areas, and even less in the Korean context.

---

* Participation in moderate-to-vigorous activity in Community Health Survey Report represent the proportion of respondents who did 3 days of vigorous activity, with each day lasting at least 20 minutes, for the past one week, or those who did 5 days of moderate activity for the past one week, with each day lasting at least 30 minutes.

1-2. Objective

For the current study, the relationship will be analysed for individual socio-demographic and socio-economic factors as well as different types of environmental features that characterize the communities to determine which factors are important in physical activity.

The aim is to investigate recreational physical environments and their relation to physical activity in a sample of residents residing in the city of Seoul, Korea. Hence, it can be hypothesized that environmental factors on the community-level are associated with individual's engagement in recommended level of moderate-to-vigorous physical activity. Further, we hypothesized that residence in communities with greater physical activity and built environment resources would be associated with a greater likelihood of meeting guidelines for physical activity.

Chapter 2. Methods

2-1. Study Design and Population

This study was designed to elucidate the relationship between environmental factors and self-reported physical activity for residents in Seoul, Korea. This cross-sectional study used combined data from two separate data sets, with community regions as the primary sampling unit. The individual-level data came from a study of Community Health Survey (CHS) conducted in 2010. The CHS is an annual, nationwide survey conducted by Public Health Centres from each community region (hereafter, "Gu" and "community" will be used interchangeably) throughout Korea in collaboration with the Korean Centre for Disease Control and Prevention (KCDC) and Universities around the nation. The second data set from which the community-level data was collected was from Seoul Statistics database. Seoul Statistics provides free access to socio-demographic as well as environmental information according to each community in Seoul. Information on the community-level data was matched with the 2010 CHS data for all respondents with regards to their residing community region (Gu).

For the purpose of the present study, data was available from 22,332 subjects residing in 25 Gu in Seoul, with an average of approximately 893 residents for each community region. As with the issue of selecting the geographic unit, there is no set rule in determining whether it is defined by geographically or by the residents' perceived boundaries (Li et al, 2005). Due to the nature of 2010 CHS and Seoul Statistics data set, for this analysis, municipality-defined 25 community regions (Gu) was selected and used as the geographic study unit.

2-2. Data Collection

Community Health Survey (2010)

The CHS, first commenced in 2008, is an annual national cross-sectional survey conducted in the months of September through to November, and estimates prevalence of behavioural risk factors for each geographical unit. Subjects that were recruited as part of the CHS were randomly selected households in which residents, 19 years and older, resides at, are notified by mail to participate in an annual survey. After a full explanation of the study, written informed consent was obtained from those who agreed to participate and face-to-face interview type survey was conducted by responding to questions by trained investigators using computer-assisted personal interview (CAPI) procedures in the participants' homes. Data collectors (investigators) participated in a centralized training to ensure standardized procedures and protocols. The survey included an extensive array of questions about the health behaviour, vaccinations, chronic diseases, injuries, quality of life, usage of health services, as well as people's perception of social and physical environment and their socio-economic status.

Seoul Statistics Database

Data for all potential areas for physical activity in each Gu, including both public and private recreational facilities hypothesized or supported by evidence to be related to physical activity was identified and obtained from the most recently updated Seoul Statistics database. Information on facilities including local exercise areas, area of green space, bicycle roads, fitness centres, football fields and swimming pools were available for the same year as the CHS.

2-3. Measures

Individual-level Independent Variables

At the individual-level, six variables that were collected from the 2010 CHS were categorized and controlled for in the analysis (Table 1). These factors were selected as previous studies have shown a relationship with physical activity. Age was categorized into six groups: 19-29, 30-39, 40-49, 50-59, 60-69, and 70 and older. Gender compared males with females. With regards to the three socio-economic characteristics, education level was classified into those with less than high school, high school, and college or higher level of education. Occupation was grouped into three categories of Professional/ Administrative/Clerical, Sales/Service/Manual Worker, and Others, which consists of soldiers, students, housewives, and unemployed. Monthly household income compared less than 100 with 101-250, 251-400, and greater than 400, where units are in ten-thousand Korean Won. In addition, a binary variable describing respondents' perception of accessibility to facilities for physical activity as being easy or difficult was included as an individual-level variable.

Community-level Independent Variables

In order to elucidate factors of environment that promote physical activity, it is important to use clear conceptual frameworks and accurate measures of characteristics. For this study, a framework developed by Pikora et al (2003) that recognizes four characteristics of the community with the likelihood of people doing physical activity, particularly walking, was used to identify the community-level variables.

The four features are firstly, functional features that represent the physical attributes of the streets and paths, and secondly, safety features, which are the safe physical environmental settings that characterizes an area or region. The third feature is neighbourhood aesthetics that shows the existence of parks and green space, and finally, destination feature represents the availability and accessibility to desired facilities within an area.

Functional features corresponds to the total length of footpath and the total length of bicycle/walking road summary measures that were calculated for this study. Number of street-lights in each community was considered as a safety feature, and density of green space, which included areas of green space surrounding buildings, schools and apartment, were considered as an aesthetics characteristic. Two summary measures were created for the destinations feature. Number of private facilities per 1,000 people consisted of private swimming pools, golf practice centres, fitness centres, dance schools, and martial arts including taekwondo, boxing, judo and kendo. Number of public facilities per 1,000 people included football and baseball fields, tennis courts, local exercise areas, and public swimming pools. The definition of facilities for the purpose of this study is an organizational structure that exists to offer programs and services for physical activity (Riva et al, 2007).

Area-based deprivation index, which was divided into quintiles, was adapted from Son (2002) that included five indices: proportion of residents living in overcrowded households, proportion of unemployed males (between ages of 15 to 64), proportion of unskilled workers, proportion of residents living in rented properties, and proportion of residents living in households with insufficient housing facilities.

Population density (gross population density), also divided in to quintiles, was calculated as total number of population in each Gu, divided by the total area. Data for population and area was obtained from Seoul Statistics database.

Outcome Variable

Levels of physical activity for the past one week were assessed by using 2010 CHS. Days of vigorous physical activity during the past week was determined by asking subjects, "During the last one week, on how many days did you participate in any vigorous physical activities for at least 10 minutes, which required hard physical effort and made you breathe hard than normal?" and the duration of was recorded as hours and minutes by asking, "How much time did you usually spend on one of those days doing vigorous physical activities?". Moderate physical activity was determined by the same method. The section on physical activities in 2010 CHS included recreational or leisure-time physical activity, as well as accounting for physical activity involved in transportation (e.g. walking, cycling) and occupation (e.g. carrying heavy objects).

Global Recommendations on Physical Activity for Health (WHO, 2010) indicates that at least 75 minutes of vigorous-intensity physical activity per week, or at least 150 minutes of moderate-intensity activity for adults is needed to be healthy.

Hence, for this study, physical activity was analyzed as a binomial outcome with those who meet the recommendations by doing more than 75 minutes of vigorous physical activity or more than 150 minutes of moderate physical activity (active) compared with those with low reporting or do not meet the recommended levels of physical activity (insufficiently active)

2-4. Multilevel Model

In social, medical and biological sciences, data are usually structured in multi-levels, or a hierarchy, such as individuals nested within clusters or groups. Making inferences across levels (cross-level inference) cause methodological problems that have been identified in past epidemiological research. Aggregated data used to draw inferences at the individual-level, and individual-level data used to analyze associations at the group-level leads to ecological fallacy and individualistic fallacy, respectively. This is because the associations that are observed at one level are not necessarily representative of the associations in the other level, which results in failure to recognize unique relationships observable at multiple levels (Subramanian et al, 2003).

To address these problems that arise with clustered data, the appropriate method to analyze is by multilevel modeling. Multilevel analysis examines the joint role of individual-level and community-level variables in explaining the variation in physical activity between individuals and communities (Li et al, 2005).

In this study the data had a multilevel structure that comprised of individuals in the lower level (level 1) nested within communities at the higher level (level 2). This two-level structure was taken into account for the analysis, with individual outcome measures of physical activity and community-level exposure measure of physical activity resources.

2-5. Statistical Analysis

Initially, descriptive statistics and chi-squared test for the sample population and physical activity was conducted to compare the distribution of subjects in each category across explanatory variables.

To investigate the relationship between environmental factors on the community-level and whether or not individuals meet the public health recommendations for physical activity, a two-level data structure that consisted of individual-level and community-level variables was tested and fitted by using multilevel logistic regression analysis. For the community-level part of the model, the sample size was 25, and the individual-level part of the model had a sample size of 22,332. Both individual-level and community-level variables were entered as fixed effects, while the community-level intercept was considered as random effect, with the assumption of normal distribution with a mean of zero.

For the dichotomous outcome of meeting physical activity guidelines, multilevel analysis was modelled using the binomial response distribution and the Logit link function (Heinrich et al, 2007). In addition, the physical environment community-level variables (number of private facilities, number of public facilities, density of green space, number of street-lights, length of footpath, and length of bicycle road) were analysed by comparing the top quartile group with the remainder as the reference group.

A five-step modelling strategy was employed in this research. First, a random intercept-only model was fitted to examine the community-level variance in physical activity without adjusting for any individual-level or community-level variables (model 1). The individual-level variables were included in model 2 and physical environment community-level variables were added in model 3. Then, area-level deprivation index was entered in model 4, and finally, model 5 included all variables, including population density.

All statistical analyses were conducted using SAS 9.3 (SAS Institute Inc., Cary, NC, 2011) and multilevel logistic regression analysis was fitted using PROC GLIMMIX. The results are shown as odds ratio (OR) with a 95% confidence interval (CI) and a 5% significance level was used.

In order to evaluate the importance of community-level effects in physical activity, percentage change in variation (PCV) and median odds ratio (MOR), as proposed by Larson and Merlo (2005), was calculated. PCV represents the percentage of community-level variance in the empty model that was attributable to a more complex model, and can thus be calculated by using the formula:

$$PCV = [(V_0 - V_1) / V_0] \times 100$$

where V_0 is variation of physical activity in the initial model and V_1 is the variance in a more complex model.

The MOR converts the variance of physical activity at the community-level into the commonly used odds ratio scale, which then can be compared directly with the ORs of individual-level and community-level variables (Hjerpe et al, 2010). MOR can be calculated by:

$$MOR = \exp[\sqrt{(2 \times V_A)} \times 0.6745] \approx \exp(0.95 \sqrt{V_A})$$

where V_A = area-level variance. Hence, the MOR depends directly on the community-level variance of physical activity (Ohlsson et al, 2005). The MOR shows whether the individual probability of being active is determined by residential area (Merlo et al, 2006), hence if the MOR is equal to 1, there would be no differences between communities in probability of being active. However, if strong area level differences are present, then the MOR would be expected to be large.

Chapter 3. Results

Table 1 shows the general socio-demographic characteristics of the study population from 2010 CHS. Among the total of 22,232 subjects from 25 communities, 6,973 people (31.4%) met the physical activity guidelines recommended by the WHO. There were more females (55.3%) than males, and 60.1% of the samples were between 19-49 years old. Slightly more than half of the participants had attained an educational level of college or higher (50.7%) and more subjects reported easy access to physical activity facilities (81.4%) compared to those who perceived a difficult accessibility.

The community-level characteristics that were assessed for each of the 25 communities are shown in table 2, including the definition of each variable. The average numbers of private and public facilities per 1,000 people were 0.61 and 0.24 respectively. Density of green space in the 25 communities showed a mean of 1.88, while the average of the total number of street-lights was approximately 6,488. Also, the length of footpath and bicycle/walking roads showed an average of 100.96km and 23.35km, respectively.

Table 1.
Individual-level socio-demographic characteristics of study participants

Variable	Population n %	Active (MVPA)* n %	Insufficiently Active* n %	p[1)]
Total	22,232 (100.0)	6,973 (31.4)	15,259 (68.6)	
Individual-level characteristics				
Age				
19-29 years	3,954 (17.8)	1,248 (17.9)	2,706 (17.7)	<.0001
30-39 years	4,949 (22.3)	1,351 (19.4)	3,598 (23.6)	
40-49 years	4,443 (20.0)	1,518 (21.8)	2,925 (19.2)	
50-59 years	3,931 (17.7)	1,475 (21.2)	2,456 (16.1)	
60-69 years	2,932 (13.2)	971 (13.9)	1,961 (12.9)	
70+ years	2,032 (9.1)	410 (5.9)	1,613 (10.6)	
Gender				
Male	9,930 (44.7)	3,871 (55.5)	6,059 (39.7)	<.0001
Female	12,302 (55.3)	3,102 (44.5)	9,200 (60.3)	
Education level[2)]				
Less than High School	4,673 (21.1)	1,182 (17.0)	3,491 (23.0)	<.0001
High School	6,265 (28.3)	1,885 (27.1)	4,380 (28.8)	
More than College	11,226 (50.7)	3,885 (55.9)	7,341 (48.3)	
Occupation[3)]				
Others[4)]	9,602 (43.3)	2,827 (40.6)	6,775 (44.4)	<.0001
Sales/Service/Manual Worker	6,015 (27.1)	1,922 (27.6)	4,093 (26.9)	
Profession/Admin/Clerical	6,585 (29.7)	2,209 (31.8)	4,376 (28.7)	
Monthly Household Income[5)]				
<100	5,434 (24.4)	1,543 (22.1)	3,891 (25.5)	<.0001
101-250	5,460 (24.6)	1,603 (23.0)	3,857 (25.3)	
251-400	5,536 (24.9)	1,761 (25.3)	3,775 (24.7)	
401+	5,802 (26.1)	2,066 (29.6)	3,736 (24.5)	
Perceived Accessibility				
Difficult	4,128 (18.6)	1,049 (15.0)	3,079 (20.2)	<.0001
Easy	18,104 (81.4)	5,924 (85.0)	12,180 (79.8)	

* Meeting physical activity guidelines of ≥75 minutes of vigorous, or ≥150 minutes of moderate physical activity per week 'Active' defined as those who meet the guidelines, and 'Insufficiently Active' are those who did not meet the guidelines

1) Significance was tested by χ^2-test

2) Missing=68

3) Missing=30

4) Others include: Soldiers, Students, Housewives and Unemployed

5) Units: Man-won (₩10,000)

Table 2.
Objective measures of environmental characteristics in the 25 communities (Gu) in Seoul, 2010

Variable	Definition	Mean	SD	Min	Max
Private facilities per 1,000 people	Number of private recreational facilities/ population of community x 1,000	0.61	0.20	0.39	1.41
Public facilities per 1,000 people	Number of public recreational facilities/ population of community x 1,000	0.24	0.14	0.07	0.68
Green space (m^2) density	Area of green space/ Total area of community * 100	1.88	0.87	0.51	4.00
No. of street-lights	Total number of street-lights in the community	6488.32	1895.23	4191	11530
Footpath length (km)	Total length in kilometers of footpaths (side-walks) in the community	100.96	34.22	55.06	164.20
Bike/walking path length (km)	Total length in kilometers of bicycle paths and bicycle-walking paths	23.35	23.96	2.00	109.00

Figure 1a-1f provides a visual representation, using Quantum GIS v1.7.4, of the 25 Gu in Seoul, and the distribution of the physical environment characteristics mentioned above.

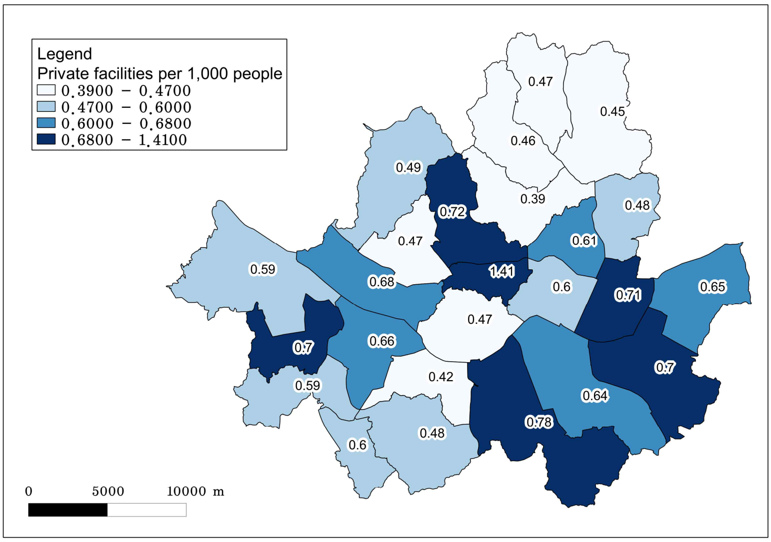

Figure 1a. Distribution of number of private facilities per 1,000 people in 25 Gu, Seoul 2010.

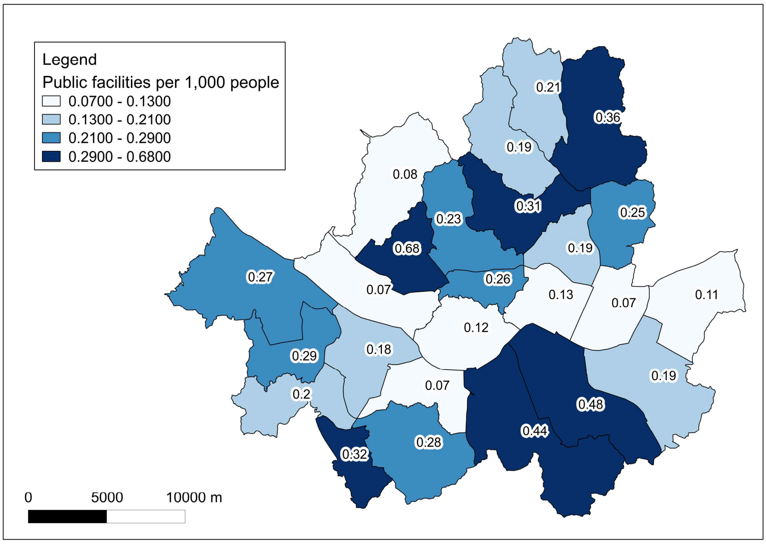

Figure 1b. Distribution of number of public facilities per 1,000 people in 25 Gu, in Seoul 2010.

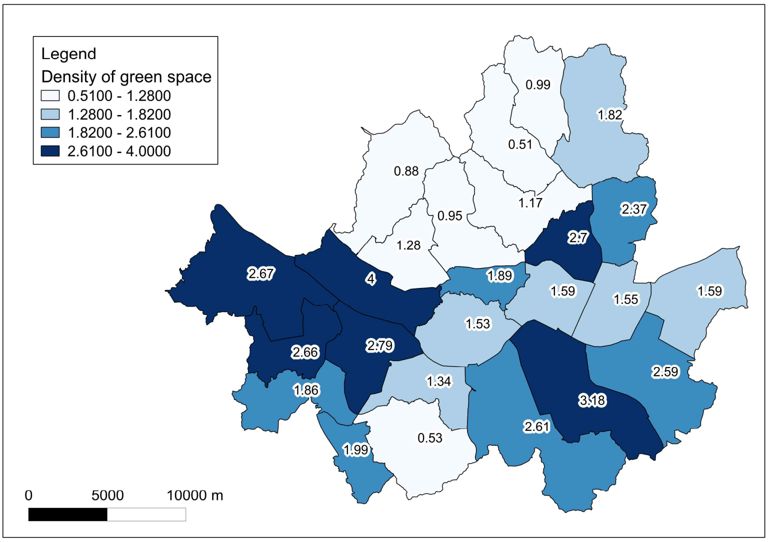

Figure 1c. Distribution of density of green space in 25 Gu in Seoul, 2010.

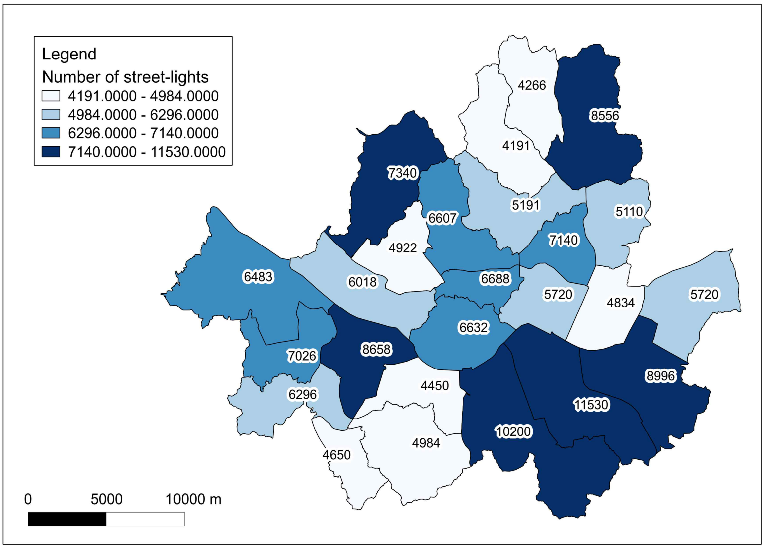

Figure 1d. Distribution of the total number of street-lights in 25 Gu in Seoul, 2010.

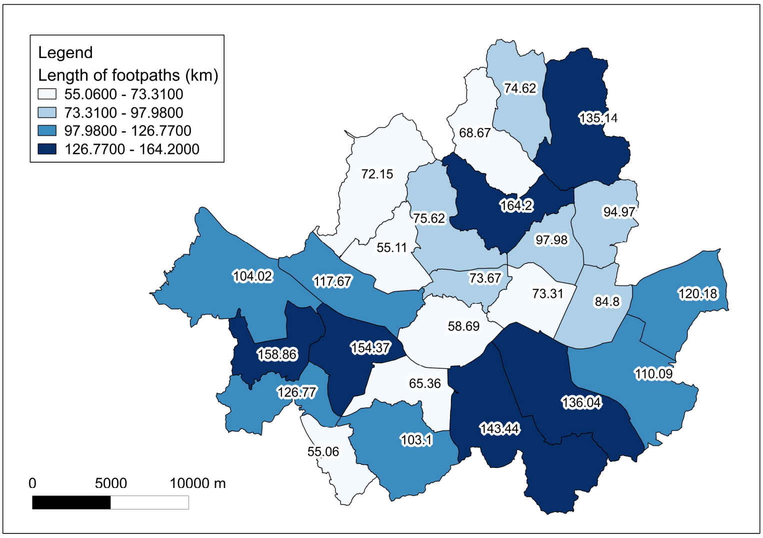

Figure 1e. Distribution of the total length, in kilometres, of footpaths in 25 Gu in Seoul, 2010.

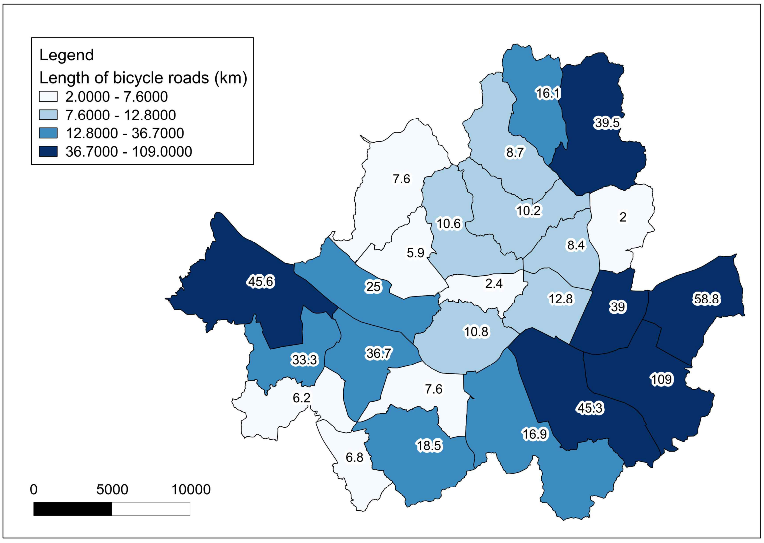

Figure 1f. Distribution of the total length in kilometres, of bicycle roads in 25 Gu in Seoul, 2010.

Pearson correlation coefficient matrix of the community-level characteristics, measured as continuous variables, is shown in table 3. Moderate positive correlations were found between number of private facilities per 1,000 people and density of green space (Pearson r=0.31) and number of street-lights (0.29), however were not significant. Number of private and public facilities were uncorrelated (r=-0.01). Density of green space was moderately positively correlated with the number of street-lights (r=0.56) and length of footpaths (r=0.48). Also, the numbers of street-lights were significantly correlated with length of footpaths (r=0.54) and bicycle/walk road (r=0.45).

Table 3.
Pearson correlation coefficient matrix for community-level measures (n=25)

	Private	Public	Green Space	Street-light	Footpath	Bicycle/ Walk road
Private	1.00	-0.01	0.31	0.29	0.03	0.09
Public	-	1.00	0.07	0.29	0.16	-0.07
Green Space	-	-	1.00	0.56[a]	0.48[a]	0.36
Street-light	-	-	-	1.00	0.54[a]	0.45[a]
Footpath	-	-	-	-	1.00	0.38
Bicycle/ Walk road	-	-	-	-	-	1.00

Note: 'Private', 'Public', 'Green Space', 'Street-light', 'Footpath' and 'Bicycle/Walk road' represent the number of private and public facilities per 1,000 people, density of green space, total number of street-lights, total length of footpaths, and total length of bicycle/walking road in the community, respectively

[a] Statistically significant at 0.05 level

The results from the multilevel logistics regression models in table 4 show that after all individual-level and community-level characteristics were included (model 5), the odds of being active increases then decrease with age, and females are less likely to be active (OR: 0.52, 95% CI: 0.49-0.56). Also, increase in level of education and monthly household income leads to being more active (OR; 1.54, 95% CI: 1.38-1.71; OR: 1.20, 95% CI: 1.09-1.31 respectively). Subjects who had a more professional occupation type displayed lower odds of meeting recommended levels of physical activity with OR of 0.87 (95% CI: 0.80-0.95) for those who were sale/service/manual workers, and OR of 0.83 (95% CI: 0.76-0.90) for those who were professional/administrative/clerical workers. Respondents with easy access to facilities were more likely to report being active (OR: 1.28, 95% CI: 1.18-1.40).

With community-level variables in model 3, only the number private facilities per 1,000 people was significantly associated with being active (OR: 1.28, 95% CI: 1.03-1.58) (Mass et al, 2008). With addition of area deprivation index in model 4, the OR increased to 1.36 (95% CI: 1.05-1.77), but model 5 showed no significant association.

In the null model (model 1), there was significant variability between communities of whether or not individuals' meet the recommended levels of physical activity. After the inclusion of individual-level characteristics (model 2), the community-level variance of physical activity was decreased slightly, and in model 5 where both individual socio-demographic characteristics and environmental features of the community-level characteristics were added, the variance was reduced even further.

Addition of individual factors in model 1 explained 10.9% of the variance from the null model, and adding physical environment factors at the community-level explained a further 1.3%, and area deprivation index was able to increase PCV by

3.3%. Finally, inclusion of all variables in model 5 explained 30.5% of the variance of physical activity between areas in the null model. MOR of the empty model was 1.23, and after addition of individual-level variables and community-level variables, the MOR was reduced to 1.19.

Table 4.

Multilevel logistic regression analysis of individual and community characteristics with recommended levels of physical activity[1] (n=22,332)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Individual-level characteristics		OR 95% CI	OR 95% CI	OR 95% CI	OR 95% CI
Age					
19-29 years		REF	REF	REF	REF
30-39 years		**0.86 (0.77-0.95)**	**0.86 (0.77-0.95)**	**0.86 (0.77-0.95)**	**0.86 (0.77-0.95)**
40-49 years		**1.28 (1.15-1.42)**	**1.28 (1.15-1.42)**	**1.28 (1.15-1.42)**	**1.28 (1.15-1.42)**
50-59 years		**1.64 (1.47-1.83)**	**1.64 (1.47-1.83)**	**1.64 (1.47-1.83)**	**1.64 (1.47-1.84)**
60-69 years		**1.39 (1.22-1.57)**	**1.39 (1.22-1.57)**	**1.39 (1.22-1.57)**	**1.39 (1.22-1.57)**
70+ years		**0.70 (0.60-0.81)**	**0.70 (0.60-0.81)**	**0.70 (0.60-0.81)**	**0.69 (0.60-0.81)**
Gender					
Male		REF	REF	REF	REF
Female		**0.52 (0.49-0.56)**	**0.52 (0.49-0.56)**	**0.52 (0.49-0.56)**	**0.52 (0.49-0.56)**
Education level					
Less than High School		REF	REF	REF	REF
High School		**1.19 (1.07-1.31)**	**1.18 (1.07-1.31)**	**1.18 (1.07-1.31)**	**1.18 (1.07-1.31)**
More than College		**1.54 (1.38-1.72)**	**1.54 (1.38-1.72)**	**1.54 (1.38-1.71)**	**1.54 (1.38-1.71)**
Occupation					
Others[2]		REF	REF	REF	REF
Sales/Service/Manual Worker		**0.87 (0.80-0.95)**	**0.87 (0.80-0.95)**	**0.87 (0.80-0.95)**	**0.87 (0.80-0.95)**
Profession/Admin/Clerical		**0.83 (0.76-0.90)**	**0.83 (0.76-0.90)**	**0.83 (0.76-0.90)**	**0.83 (0.76-0.90)**
Monthly Household Income[3]					
<100		REF	REF	REF	REF
101-250		1.01 (0.92-1.11)	1.01 (0.92-1.11)	1.01 (0.93-1.11)	1.01 (0.92-1.11)
251-400		1.10 (1.00-1.20)	1.10 (1.00-1.20)	1.10 (1.00-1.20)	1.10 (1.00-1.21)
401+		**1.20 (1.09-1.31)**	**1.20 (1.09-1.31)**	**1.20 (1.09-1.31)**	**1.20 (1.09-1.31)**
Perceived Accessibility					
Difficult		REF	REF	REF	REF
Easy		**1.28 (1.18-1.40)**	**1.28 (1.18-1.40)**	**1.28 (1.18-1.40)**	**1.28 (1.18-1.40)**
Community-level characteristics					
Physical Environment					
Private facilities per 1,000 people					
Base			REF	REF	REF
Top Quartile			**1.28 (1.03-1.58)**	**1.36 (1.05-1.77)**	1.27 (0.93-1.74)
Public facilities per 1,000 people					
Base			REF	REF	REF
Top Quartile			1.03 (0.80-1.33)	1.07 (0.81-1.42)	1.14 (0.86-1.50)
Green space (m^2) density					
Base			REF	REF	REF
Top Quartile			1.07 (0.85-1.34)	1.05 (0.82-1.34)	1.06 (0.82-1.37)
No. of street-lights					
Base			REF	REF	REF
Top Quartile			0.94 (0.74-1.19)	0.88 (0.68-1.13)	0.94 (0.72-1.23)
Footpath length (km)					
Base			REF	REF	REF
Top Quartile			0.96 (0.73-1.26)	0.86 (0.61-1.22)	0.87 (0.62-1.21)
Bike/walking path length (km)					
Base			REF	REF	REF
Top Quartile			0.97 (0.78-1.22)	0.97 (0.75-1.26)	1.02 (0.78-1.32)
Deprivation Index					
First Quintile (Lowest)				REF	REF
Second Quintile				1.29 (0.88-1.90)	1.29 (0.86-1.91)
Third Quintile				1.27 (0.86-1.87)	1.15 (0.77-1.71)
Fourth Quintile				1.14 (0.81-1.59)	1.04 (0.73-1.46)
Fifth Quintile (Highest)				1.37 (0.98-1.92)	1.24 (0.88-1.75)
Population Density					
First Quintile (Lowest)					REF
Second Quintile					0.75 (0.53-1.06)
Third Quintile					1.02 (0.74-1.40)
Fourth Quintile					0.87 (0.62-1.21)
Fifth Quintile (Highest)					0.83 (0.62-1.12)
Variance (SD)[4]	**0.046 (0.018)**	**0.041 (0.014)**	**0.040 (0.015)**	**0.039 (0.017)**	0.032 (0.017)
PCV[5]	REF	10.9%	12.2%	15.6%	30.5%
MOR[6]	1.23	1.21	1.21	1.21	1.19

1) Dichotomous outcome of meeting physical activity guidelines: ≥75 minutes of vigorous, or ≥150 minutes of moderate physical activity per week

2) Others include: Soldiers, Students, Housewives and Unemployed

3) Units: Man-won (₩10,000)

4) Variance component is not an odds ratio, but the estimated parameter

5) Percentage change in the variance = $[(V_0 - V_1) / V_0] \times 100$, where V_0=variation of null model, V_1=variation of complex model

6) Median odds ratio = $\exp[\sqrt{2 \times V_A} \times 0.6745] \approx \exp(0.95 \sqrt{V_A})$, where V_A=area-level variation of the model

Note: **Bold** indicates statistically significance at 5% level

Model 1: Null model

Model 2: Individual characteristics

Model 3: Individual + Community level physical environment characteristics

Model 4: Individual + Physical Environment + Deprivation Index

Model 5: Individual + Physical Environment + Deprivation Index + Population Density

Chapter 4. Discussion

The results showing a significant association between individual-level characteristics and the likelihood of being active are similar to findings from previous studies. With age, the middle-aged subjects had the highest odds of meeting recommended levels of physical activity. Also, subjects who lacked of physical activity were mainly old, and women (Santos et al, 2009). The higher the education attainment levels, the increased odds of meeting physical activity guidelines, which was similar to a study of 5,600 people aged between 20 to 80 in Sweden that showed education as a strong determinant of meeting physical activity (Lindstrom et al, 2003), and another study showed that increase in level of education was positively associated with physical activity (Santana et al, 2009). However, education shows different findings as a separate study demonstrated that high education level was related to a lack of physical activity (Santos et al, 2009).

Models 4 and 5 in Table 4 showed that deprivation index and population density, both divided into quintiles were not associated with engagement of recommended levels of physical activity. This corresponds with results shown by Santana et al. (2009), however, there are studies that have demonstrated a significant association. Residents living in the most deprived areas, measured using CNI (Care Need Index) and Townsend scores, showed increased risk of physical inactivity when adjusted for age, gender, individual SES as confounders (Sundquist et al, 1999). Also, after adjusting for individual socio-demographic factors, smoking status, body mass index, and alcohol consumption, decline in physical activity was shown for people living in poverty area (Yen and Kaplan, 1998).

Population density, as Forsyth et al (2007) mentions, did not affect physical activity and showed that the correlations for overall physical activity measured by IPAQ (International Physical Activity Questionnaire), travel diary and accelerometer were small that they showed no relationship between density and physical activity. In addition, County Sprawl index, in which the population density variable is included, was not associated with either 'any physical activity' or 'recommended physical activity' (Ewing et al, 2008).

In the present study, the MOR of the empty model was 1.23, indicating that if an individual was randomly selected in a community with a higher probability of physical activity, the odds of meeting recommended level of physical activity is 1.23 times higher than that of an individual that resides at a community with lower probability of physical activity.

The results from the current study found that only the number of private facilities per 1,000 people were associated with meeting physical activity guidelines. This is similar to several previous studies that have documented a positive association between physical activity and the number of facilities available. One study by Parks et al (2003) showed that as the more physical activity resources are available, the likelihood of meeting recommended levels of physical activity increased. The authors demonstrated that having one, two, or three, places for physical activity, the odds ratios were 1.14, 2.11, 3.87, respectively, for urban lower income subjects, and 3.14, 6.34 and 8.69 for urban higher income residents, respectively. Another study by Santana et al (2009) investigating the link between local environment and physical activity in the Lisbon Metropolitan Area, Portugal, showed evidence of significant positive association between the number of swimming pools (OR: 1.17, 95% CI: 1.01−1.35) and gymnasiums (OR: 1.17, 95% CI: 1.01−1.36) with vigorous physical activity.

Contrary to the hypothesis, having more resources, other than private facilities, was not associated with meeting physical activity guidelines. Several studies have also shown mixed results. A study of 4,899 Dutch people showed that no relationship was found between amount of green space in the environment and whether or not people meet the Dutch public health recommendations for physical activity (Maas et al, 2008). Study of the relationship between neighbourhoods and physical activity in a sample of 4,727 adults (Prince et al, 2012) and in a sample of 3,883 adults in Ottawa, Canada (Prince et al, 2011) showed physical activity did not associate with neighbourhood facilities or aesthetics (Deforche et al, 2010), green space area (km^2) per 1,000 people and total bike and walking path length (km). Several other studies have shown no significant association with facilities per 1,000 residents (Riva et al, 2007), existence of bike paths (Gomez et al, 2010), footpaths and street−lights (Amorim et al, 2010).

A possible explanation for these mixed results is that although the facilities for physical activity are available to the community, the residents are not utilizing the resources (Heinrich et al, 2007). Hence, the presence of physical activity resources that are available does not necessarily represent information on usage of the resources. However, for the current study, data on utilizing resources by community residents was not available.

Also, self−selection is a theory that suggests residents who are more likely to participate in physical activity choose to live in communities or neighbourhood that provides more opportunities of physical activity. This may consequently bias the estimation of the independent association of physical activity and the environment (Hoehner et al, 2011) and some studies of the relationship between community−level characteristics and physical activity, have shown that self−selection explains the observed associations to some extent

(Frank et al, 2007). Unfortunately, this study lacked data on self-selection to test this theory. However, Bentley et al (2010) suggests that socio-economic factors, such as income and occupation, as well as socio-demographic factors, such as age and sex, are likely to partial explain the effect of confounding by self-selection.

In theory, the environment surrounding a neighbourhood or community effectively provides the setting to promote physical activity, and this study adds to the evidence from previous studies that availability of facilities are significantly associated with meeting recommended levels of physical activity. However, as Cohen et al (2009) indicates, there is a lack of strong evidence to support the role in which the environment plays in promoting physical activity.

The major strengths of this study were the large randomly sampled study population from the 2010 CHS and objective measures of community-level characteristics. Past studies that have used both objective measures and self-reported measures of the environmental factors were able to explore the relationship between physical activity and the environment. However, self-reported measures of the environment may be misleading as it reflects individual biases, hence the objective measures may be preferable over self-reported measures (Heinrich et al, 2007). In addition, information on the community-level variables was collected and available for the same year as the 2010 CHS, where individual-level variables were collected. Therefore, this allows the error from misclassification of community-level exposure as a result of changing environment over time to be reduced. Also, by using multilevel analysis method, this study was able to assess the effect and explain community-level variation in physical activity.

4-1. Limitations

This study has a number of limitations. Firstly, due to the cross-sectional nature of this study, assessment of causality in the relationship between physical activity and individual-level and community-level variables was not clearly distinguishable.

Secondly, although the sufficient sample size of randomly selected subjects in each community may be representative of the Metropolitan city of Seoul, the communities in Seoul, in general, do not represent other Korean community regions.

Thirdly, individual-level factors and physical activity outcome were collected from a self-reported survey, hence this may lead to self-report or recall bias. Also, self-reported physical activity results in low reliability and validity compared with objective physical activity measures, such as of that collected by an accelerometer (Prince et al, 2008). But several studies using objective measures of physical activity have shown varied results.

Fourth, using the municipality-defined 25 Gu as a geographical unit may be too large to be considered as a community, but a smaller area for selection was not possible because of the nature of community-level data. Individual's definition of their communities or neighborhoods may not be considered as census boundaries or other objective measures. However, selecting a larger geographical unit may increase the within-community heterogeneity of both outcome and independent variables (Li et al, 2005). Also, this study was unable to account for the fact that individuals were likely to cross community boundaries to utilize other facilities

Fifth, some additional environmental factors such as street connectivity, or factors related to social capital were not included in this study that may explain the physical activity at a community-level. In addition, since the separate environmental factors, such as swimming pools and gymnasiums were grouped into a single variable, such as the number of public and private physical activity facilities, a particular aspect of the facilities that may be important for physical activity was unable to be identified.

Chapter 5. Conclusion

Meeting recommended levels of physical activity was found to have statistically significant differences between communities in Seoul, Korea. Individual and community-level characteristics explained some, but not all, of the difference.

This study provides evidence physical activity is strongly related to the facilities available to the community. Community based interventions may be appropriate for promoting physical activity, however individual factors must not be disregarded, as these characteristics show a strong association with physical activity.

References

1. Amorim TC, Azevedo MR, Hallal PC. Physical activity levels according to physical and social environmental factors in a sample of adults living in south Brazil. *Journal of Physical Activity and Health*. 2010, 7(Suppl 2): S204-212.
2. Bentley R, Jolley D, Kavanagh AM. Local environments as determinants of walking in Melbourne, Australia. *Social Science & Medicine*. 2010, 70: 1806-1815.
3. Cohen DA, Sehgal A, Williamson S, Marsh T, Golinelli D, McKenzie TL. New recreational facilities for the young and the old in Los Angeles: Policy and Programming implications. *Journal of public health policy*. 2009, 30:S248-S263.
4. Deforche B, Van Dyke D, Verloigne M, De Bourdeaudhuij I. Perceived social and physical environment correlates of physical activity in older adolescents and the moderating effect of self-efficacy. *Preventive Medicine*. 2010, S24-S29.
5. Dishman RK, Sallis JF. Determinants and interventions for physical activity and exercise. In: Bouchard C, Shephard RJ, Stephens T, eds. Physical activity, fitness, and health: international proceedings and consensus statement. Champaign, IL: *Human Kinetics*. 1994, 214-38.
6. Ewing R, Schmid T, Killingsworth R, Zlot A, Raudenbush S. Relationship between urban sprawl and physical activity, obesity, and morbidity. *American Journal of Health Promotion*. 2003, 18(1): 47-57
7. Fisher KJ, Li F. A community-based walking trial to improve neighborhood quality of life in older adults: a multilevel analysis. *Ann Behav Med*. 2004, 28(3): 186-194.
8. Fisher KJ, Li F, Michael Y, Cleveland M. Neighborhood-level influences on physical activity among older adults: A multilevel analysis. *Journal of Aging and Physical Activity*. 2004, 11: 45-63.
9. Forsyth A, Oakes JM, Schmitz KH, Hearst M. Does residential density increase walking and other physical activity? *Urban Stud*. 2007, 44: 679

10. Frank LD, Saelens BE, Powell KE, Chapman JE. Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving and obesity? *Social Science and Medicine*. 2007, 65: 1898-1914.
11. Giles-Corti B, Donovan R. Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. *Preventative Medicine*. 2002, 35:601-611.
12. Gomez LF, Sarmiento OL, Parra DC, Schmid TL, Pratt M, Jacoby E, Neiman A, Cervero R, Mosquera J, Rutt C, Ardila M, Pinzon. Characteristics of the built environment associated with leisure-time physical activity among adults in Bogota, Columbia: A multilevel study. *Journal of Physical Activity and Health*. 2010, 7(Suppl 2): S196-S203.
13. Hahn RA, Teutsch SM, Rothenberg RB, Marks JS. Excess deaths from nine chronic diseases in the United States. *JAMA*. 1990, 264:2654-2659.
14. Heinrich KM, Lee RE, Suminski RR, Regan GR, Reese-Smith JY, Howard HH, Haddock CK, Poston WSC, Ahluwalia JS. Association between the built environment and physical activity in public housing residents. *International Journal of Behavioral Nutrition and Physical Activity*. 2007, 4(56).
15. Hjerpe P, Merlo J, Ohlsson H, Bostrom KB, Lindblad U. Validity of registration of ICD codes and prescriptions in a research database in Swedish primary care: a cross-sectional study in Skaraborg primary care database. *BMC Medical Informatics and Decision Making*. 2010, 10:23.
16. Hoehner CM, Handy SL, Yan Y, Blair SN, Berrigan D. Association between neighborhood walkability, cardiorespiratory fitness and body-mass index. *Social Science & Medicine.* 2011, 73: 1707-1716.
17. Humpel N, Owen N, Leslie E. Environmental factors associated with adults' participation in physical activity. *Am J Prev Med.* 2002, 22(3):188-199.
18. Huston SL, Evenson KR, Bors P, Gizlice Z. Neighbourhood environment, access to places for activity, and leisure-time physical activity in a diverse North Carolina population. *American Journal of Health Promotion.* 2003, 18(1):58-69.

19. Kavanagh AM, Goller JL, King T, Damien J, Crawford D, Turrell G. Urban area disadvantage and physical activity: a multilevel analysis in Melbourne, Australia. *J Epidemiol Community Health*. 2005, 59: 934-940.
20. Larsen K, Merlo J. Appropriate assessment of neighbourhood effects on individual health: integrating random and fixed effects in multilevel *logistic regression*. Am J Epidemiol 2005, 161:81-88.
21. Li F, Fisher KJ, Bauman A, Ory MG, Chodzko-Zajko W, Harmer P, Bosworth M, Cleveland M. Neighborhood influences on physical activity in middle-aged and older adults: a multilevel perspective. *Journal of Aging and Physical Activity*. 2005, 13: 87-114.
22. Lindstrom M, Moghaddassi M, Merlo J. Social capital and leisure time physical activity: a population based multilevel analysis in Malmo, Sweden. *J Epidemiol Community Health*. 2003, 57: 23-28.
23. Maas J, Verheij RA, Spreeuwenberg P, Groenewegen PP. Physical activity as a possible mechanism behind relationship between green space and health: A multilevel analysis. *BMC Public Health*. 2008, 8:206
24. McGinnis JM, Foege WH. Actual causes of death in the United States. *JAMA*. 1993, 270:2207-2212.
25. Merlo J, Chaix B, Ohlsson H, Beckman A, Johnell K, Hjerpe P, Rastam L, Larsen K. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. *J Epidemiol Community Health*. 2006, 60:290,297.
26. Norman GJ, Adams MA, Ryan S, Frank LD, Roesch SC. A latent profile analysis of neighbourhood recreation environments in relation to adolescent physical activity, sedentary time, and obesity. *J Public Health Manag Pract*. 2010, 16(5):411-419.
27. Ohlsson H, Lindblad U, Lithman T, Ericsson B, Gerdtham U-G, Melander A, Rastam L, Merlo J. Understanding adherence to official guidelines on statin prescribing in primary health care - a multilevel methodological approach. *Eur J Clin Pharmacol.* 2005, 61(9): 657-665.

28. Omariba WR. Neighbourhood characteristics, individual attributes and self-rated health among older Canadians. *Health and Place*. 2010, 16: 986-995.
29. Owen N, Leslie E, Salmon J, Fotheringham MJ. Environmental determinants of physical activity and sedentary behavior. *Exerc Sport Sci Rev*. 2000, 28(4): 153-158.
30. Parks SE, Housemann RA, Brownson RC. Differential correlates of physical activity in urban and rural adults of various socio-economic backgrounds in the United States. *J Epidemiol Community Health*. 2003, 57:29-35.
31. Pikora T, Giles-Corti B, Bull F, Jamrozik K, Donovan RJ. Developing a framework for assessment of the environmental determinants of walking and cycling. *Social Science and Medicine*. 2003, 56: 1693-1703.
32. Prince SA, Adamo KB, Hamel ME, Hardt J, Gorber SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systemic review. *International Journal of Behavioral Nutrition and Physical Activity*. 2008, 5, 56.
33. Prince SA, Kristjansson EA, Russell K, Billette JM, Sawada MC, Ali A, Tremblay MS, Prud' homme D. A multilevel analysis of neighbourhood built and social environments and adult self-reported physical activity and body mass index in Ottawa, Canada. *Int J Environ Res Public Health*. 2011, 8: 3953-3390.
34. Prince SA, Kristjansson EA, Russell K, Billette JM, Sawada MC, Ali A, Tremblay MS, Prud' homme D. Relationship between neighbourhoods, physical activity, and obesity: A multilevel analysis of a large Canadian city. *Obesity*. 2012, 1-8.
35. Ries AV, Yan AF, Voorhees CC. The neighbourhood recreational environment and physical activity among urban youths: an examination of public and private recreational facilities. *J Community Health.* 2011, 36:640-649.
36. Riva M, Gauvin L, Riachard L. Use of local area facilities for involvement in physical activity in Canada: insights for developing environmental and policy interventions. *Health Promotion International*. 2007, 22(3): 227-235.

37. Sallis JF, Bauman A, Pratt M. Environmental and policy interventions to promote physical activity. *Am J Prev Med*. 1998, 15:379-397.
38. Sallis JF, Hovell MF, Hofstetter CR, et al. Distance between homes and exercise related facilities related to frequency of exercise among San Diego residents. *Public Health Rep*. 1990, 105: 179-185.
39. Sallis JF, Owen N. Physical activity and behavioral medicine. Thousand Oaks, CA: Sage Publications Inc., 1999.
40. Santana P, Santos R, Nogueira H. The link between local environment and obesity: a multilevel analysis in the Lisbon Metropolitan Area, Portugal. *Social Science and Medicine*. 2009, 68: 601-609.
41. Santos R, Vale S, Miranda L, Mota J. Socio-demographic and perceived environmental correlates of walking in Portuguese adults-A multilevel analysis. *Health and Place*. 2009, 15: 1094-1099.
42. Stone EJ, McKenzie TL, Welk GJ, Booth ML. Effects of Physical Activity Interventions in Youth: Review and Synthesis. *Am J Prev Med.* 1998, 15(4):298-313.
43. Subramanian SV, Jones K, Duncan C. Multilevel methods for public health research. In I. Kawachi & LF Berkman (Eds). Neighborhoods and health. New York: Oxford University Press, 2003,(pp.65-111)
44. Subramanian SV et al. Revisiting Robinson: The perils of individualistic and ecological fallacy. *Int J of Epidemiology.* 2009; 38: 342-360.
45. Sundquist J, Malmstrom M, Johansson SE. Cardiovascular risk factors and neighbourhood environment: a multilevel analysis. *Int J of Epidemiology*. 1999, 28: 841-845
46. Timperio A, Ball K, Salmon J, Roberts R, Giles-Corti B, Simmons D, Baur LA, Crawford D. Personal, familial, social and environmental correlates of active commuting to school. *American Journal of Preventative Medicine.* 2006, 30:45-51.
47. Trilk JL, Ward DS, Dowda M, Pfeiffer KA, Porter DE, Hibbert J, Pate RR. Do physical activity facilities near schools affect physical activity in high school girls? *Health and Place.* 2011, 17:651-657.

48. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. Geneva, *WHO*, 2009
49. World Health Organization. Global Recommendations on Physical Activity for Health. *WHO*, 2010.
50. Yen IH and Kaplan GA. Poverty area residence and changes in physical activity level: Evidence from the Alameda County Study. *American Journal of Public Health*. 1998, 88(11): 1709-1712.
51. Yu G, Renton A, Schmidt E, Tobi P, Bertotti M, Watts P, Lais S. A multilevel analysis of the association between social networks and support on leisure time physical activity: Evidence from 40 disadvantaged areas in London. *Health and Place*. 2011, 17: 1023-1029.
52. 박노례 등. 2010년 서울특별시 지역사회 건강통계. In. 질병관리본부, 보건복지부. 2010년 지역사회건강조사. 2011.
53. 서울특별시. 서울통계 (Access: http://stat.seoul.go.kr/)
54. 손미아. 직업, 교육수준 그리고 물질적 결핍이 사망률에 미치는 영향. 예방의학회지. 2002, 35(1): 76-82.
55. 통계청. 2010년 사망원인통계 결과. (Available: http://kostat.go.kr) 2011.

국문초록

다수준분석을 이용한 서울지역에서 신체활동과 지역특성과의 연관성

박지원
보건학과 역학전공
보건대학원
서울대학교

연구배경: 신체활동은 대부분의 만성질환의 중요한 요인으로서 한국을 포함한 세계적에서 각종 암, 뇌혈관질환과 같은 질병의 위험도를 줄여준다고 알려져 있다. 그러므로 지역사회의 건강증진으로 위해 신체활동을 증가시키는 것이 공중보건에 중요하며, 지역사회에 지역수준 요인을 제공하는 것에 관심이 증가되고 있다.

연구목적: 본 연구는 서울지역에서 권장되는 신체활동의 수준에 영향을 미치는 지역특성을 다수준분석을 통해 파악하고자 하였다.

연구방법: 분석을 위해 사용된 자료는 2010년 서울특별시 25개 구의 지역사회건강조사 대상자 22,232명의 자료와 서울통계에서 각 구의 지역특성이 포함된 자료이다. Two-level structure를 고려하여 개인수준을 포함한 지역수준 변수들과 신체활동에 대해 다수준분석 (multilevel logistic regression analysis)으로 OR값을 관찰하였다.

연구결과: 권장되는 수준의 신체활동에 참여하는 율은 31.4%였다. 다수준분석의 결과, 지역간 신체활동의 변이는 유의하게 나왔으며, 개인수준과 지역수준 변수들이 포함되었을 때 변이가 줄어들며 어느 정도의 설명력이 있다고 나타났다. 또한, 신체활동에 영향을 미치는 환경적 요인은 천명당 신고·등록시설의 수 (OR: 1.28, 95% CI: 1.04-1.58) 인 것으로 나타났다.

결론: 서울시에서 각 구간에 신체활동의 차이가 있으며, 주민의 건강의 향상을 위해 지역수준에서 이용 가능한 시설의 수가 신체활동에 영향이 있다고 나타났다.

주요어: 신체활동, 지역특성, 지역사회건강조사, 다수준분석

학번: 2010-23809

감사의 글

2010년 9월, 서울대학교 보건대학원에 입학하여 역학공부를 시작했던 때가 엊그제 같습니다. 한국에서 공부한 경험이 없어 모든 것이 낯설고 두려웠지만 설레는 마음도 있었습니다. 때로는 힘들었지만 좋은 분들을 많이 만나게 되었고 새로운 지식을 쌓는 보람 있고 행복한 시간이었습니다. 처음에 와서 한국어가 서툴러 영어로 발표하고 시험도 영어로 썼었는데 어느덧 시간이 흘러 이제는 제가 석사논문을 마치고 졸업을 하게 되었습니다.

우선, 역학과 연구에 대한 열정을 보여주시고 첫 학기부터 논문이 완성될 때까지 부족한 저에게 자상한 지도와 격려를 해주신 지도교수 조성일 교수님께 진심으로 존경과 감사의 마음을 올립니다. 항상 웃어 주시며 따뜻하게 학생들을 대해주시는 교수님의 열정적인 강의를 통해 많은 가르침을 받았습니다. 앞으로 최선을 다하여 노력하며 교수님께 부끄럽지 않은 제자가 되도록 하겠습니다. 그리고 바쁘신 와중에 저의 논문을 검토해주신 김호 교수님과 정효지 교수님께도 감사 드립니다.

대학원 생활을 하는 동안 큰 도움을 주셨던 김태훈 선생님에게도 감사의 마음을 전합니다. 때로는 선배님처럼 항상 조언을 아끼지 않고 도움을 주시고, 때로는 친형같이 반갑게 맞이해주시고 즐거운 시간을 만들어주셔서 감사 드립니다. 또한 관심과 격려를 아끼지 않으셨던 김인경 선생님, 윤규현 선생님과 노영선 선생님께 감사 드립니다. 항상 저희 후배들을 챙겨주시고 배려해 주시는 마음, 잊지 못할 것 같습니다. 그리고 이곳이 낯설었던 저에게 끊임없는 도움과 격려를 해준 이효림 선생님 감사합니다. 또한 만성병 역학교실을 빛내주시는 이희정 선생님, 김영미 선생님, 조연영 선생님, 오용호 형님, 이고운 선생님, 류보영 선생님, 김지혜 선생님과 조수경 선생님께 감사 드립니다. 그리고 매번 찾아 뵐 때 마다 친절하게 대해주시고 조언해주신 김영실 선생님께도 감사 드립니다.

또한, 보건대학원에 지원할 때 큰 도움을 준 진호, 가깝지만 자주 보지 못한 원철, 은수와 일년에 한번씩 얼굴 보며 즐거운 시간을 보낼 수 있었던 연준이와 태욱이, 고맙고, 우리 우정 평생 가자! 그리고 공부하는 스트레스와 피로를 풀게 해준 이창용 형님과 한울 축구팀, 그리고 보건대학원 축구팀 멤버 모든 분들에게 감사합니다.

마지막으로 항상 관심 가지고 조언해주신 친척분들과 준원이 형, 그리고 어느새 벌써 사회인이 된 착한 동생, 그리고 매일 좋은 말씀 많이 해주시고 항상 기도해주시는 어머니와 이 세상에서 가장 존경스럽고 제게 끝까지 믿음을 버리지 않으시고 실패를 해도 포기하지 않으셨던 멋진 아버지께 이 논문을 바칩니다.
제 인생에서 가장 기억에 남고 터닝포인트가 된 보건대학원에서 받은 많은 사랑과 은혜를 갚으며 세상에 베푸는 사람으로 살아가겠습니다.

감사합니다.

2012년

박지원 올림